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(54) Analyzer incubators.

(57) In some immunoassays which are carried out in clinical analyzers, the steps are time-consuming and often require batch processing of samples in more than one station. This means that throughput of the analyzer is relatively low. Described herein is an improved analyzer incubator (50) which utilizes two independently driven incubator rings (52, 54). Each ring (52, 54) supports and transports cuvettes (C) containing samples between processing stations of the analyzer. At least one reagent addition station (74, 76) is disposed permanently adjacent each of the two rings (52, 54). Enhanced throughout is obtained using more than one incubator ring (52, 54) compared with an analyzer having only one such ring for all reagent addition stations.

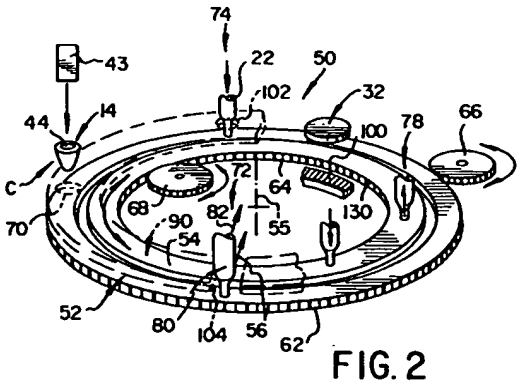

FIG. 2

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This invention relates to analyzer incubators, particularly those used to incubate liquid-containing cuvettes.

Certain immunoassays, such as thyroxine (T4) and thyroid stimulating hormone (TSH), have conventionally been done as a wet assay, that is, by using liquid reagents in a cuvette. In one such assay, the enhanced chemiluminescence system originally developed by Amersham International and sold under the tradename Amerlite®, the cuvette has an antibody for the target antigen preadhered to the cuvette. The liquid sample is added to the cuvette, followed by at least one liquid reagent containing a labeled antibody to the antigen, and the liquid mix is incubated. Following incubation, the mix in the well is aspirated out, followed by multiple washings, to separate bound labeled antibody from unbound labeled antibody. Thereafter, at least one signal generating reagent is added in liquid form to induce enhanced chemiluminescence, which is then read.

All of these steps are time-consuming in their totality. This is handled in the Amerlite system by making the operation a batch operation - the cuvettes are given the sample and first liquid reagent, and incubated, in one apparatus, and then transferred to a different apparatus for washing. Still further, a third apparatus is used for adding the signal-generating reagent and another for reading. In that manner, a first set of cuvettes can be incubating while a second one is being washed and a third is being read, to enhance throughput.

One drawback of such a system is that the three separate stations are not one automated instrument. Other instruments are known that have a single unit to provide incubation and reading, such as is described in US-A-4 699 766 wherein all incubation functions occur while the cuvette is on one of two separate rings. However, to remove a cuvette from either ring, the analyzer must use an elevator mechanism to raise the cuvette out of the plane of the ring and to lower it elsewhere. The need to provide such an elevator when movement out of the ring is desired, creates an unnecessarily complicated and expensive structure.

It is therefore an object of the present invention to provide an automated analyzer for cuvettes handling liquid reagents which automates reagent addition, incubation, washing and detection, without necessitating that the cuvettes be raised off the ring each time it is to be moved out of that particular ring.

More specifically, in accordance with one aspect of the present invention, there is provided an incubator in an analyzer for detecting an analyte, the incubator comprising:-

stationary guide track means;

a plurality of processing stations arranged around the guide track means;

support means mounted above the guide track means and operable for carrying reaction cuvettes between the processing stations, the reaction cuvettes being held at defined positions in the support means, each position being formed as an opening in the support means sized to receive and to hold the reaction cuvettes;

drive means for rotating the support means between the processing stations;

temperature control means adjacent the support means; and

transfer means for transferring a reaction cuvette from one position in the support means to another at a transfer location;

characterized in that the support means comprises plural support rings, at least one ring having a modified opening to allow transfer of cuvettes from one ring to the other;

and in that the transfer means operates to transfer a cuvette from one ring to the other at the transfer location and/or from one ring to a dump station.

In accordance with another aspect of the present invention, there is provided a method for incubating cuvettes in an incubator according to any one of the preceding claims, the method comprising the steps of:-

a) placing a cuvette and liquid sample in a defined position on one of the support rings,

b) rotating the one support ring between processing stations disposed adjacent to the support ring while incubating the contents of the cuvette,

c) transferring the cuvette to another of the support rings following partial incubation at a transfer location,

d) rotating the other support ring while incubating the contents of the cuvette and while passing through at least one reagent-addition station, and

e) ejecting the cuvette from the incubator by moving it through a notch in the other ring.

Accordingly, it is an advantageous feature of the invention that all the incubation functions of adding liquid reagent(s) and a sample to a cuvette and washing the contents of the cuvette, all while controlling the temperature of the cuvette, can be done automatically while obtaining high throughput.

It is a related advantageous feature of the invention that the cuvette washing function of the incubation can be done independently of the incubation following first liquid reagent.

It is a further advantageous feature of the invention that the incubation functions are split up into two independently driven parts of the incubator, and transfer between the two parts is achieved quickly and efficiently.

For a better understanding of the present invention, reference will now be made, by way of example only, to the accompanying drawings in which:-

Figure 1 is a schematic, broken away plan view of an analyzer incorporating one embodiment of the incubator in accordance with the present invention;

Figure 2 is a partially schematic, fragmentary isometric view of the incubator per se and of the processing stations associated therewith;

Figure 3 is a fragmentary plan view of the incubator shown in Figure 2 with the cover removed;

Figure 4 is a fragmentary isometric view similar to that shown in Figure 2, showing details of a segment of the incubator;

Figure 5 is a fragmentary plan view of the outer ring of the incubator, showing one quadrant which repeats itself around the circumference of the ring;

Figure 6 is a sectioned view taken generally along the line VI-VI of Figure 5, the associated stationary track and a cuvette being shown in phantom;

Figure 7 is a fragmentary sectional view taken generally along the line VII-VII of Figure 5, and showing a cuvette in solid lines;

Figure 8 is a fragmentary plan view of one quadrant of the inner ring, which quadrant repeats itself around the circumference of the ring;

Figure 9 is a sectioned view taken along the line IX-IX of Figure 8, the associated track and cuvette being shown in phantom;

Figure 10 is a plan view of a preferred form of the stationary track associated with the incubator;

Figure 11 is a sectioned view taken generally along the line XI-XI of Figure 10;

Figure 12 is a sectioned view taken generally along the line XII-XII of Figure 10;

Figure 13 is a plan view of just the transfer means for moving a cuvette off the incubator rings;

Figure 14 is a partially schematic, fragmentary sectioned view taken generally along the line XIV-XIV of Figure 3;

Figures 15 and 16 are fragmentary, sectioned elevational views similar to that shown in Figure 14, showing the shuttle mechanism as it moves the cuvettes from one ring to another and then out of the incubator;

Figure 17 is a sectioned view taken generally along the lines XVII-XVII of Figure 1,

Figures 18A and 18B are timing diagrams showing representative timing of the operations provided by the incubator of the invention;

Figure 19 is a schematic plan view of a second embodiment of an incubator in accordance with the present invention, wherein the rings are not concentric; and

Figure 20 is a fragmentary sectioned view taken generally along the line XX-XX of Figure 19.

The invention is hereinafter described in connection with the preferred embodiments of an incubator of an analyzer having plural processing stations disposed around concentrically mounted plural rings, of a preferred type that make use of a reaction cuvette and certain reagents, to treat a sample obtained from a sample supply station by aspiration. In addition, the invention is useful regardless of the number and type of processing stations of the analyzer, regardless of the type of cuvettes and reagents used, whether the rings are concentrically mounted or not, and regardless of how cuvettes, reagents and samples are supplied to the incubator, since those features are not the invention, as long as at least one reagent addition station is permanently disposed adjacent to at least each of the plural rings of the incubator to enhance throughput. As used herein, "reagent addition station" means, the location at the respective ring at which the function of reagent addition occurs. The apparatus used at such a station may, and in fact preferably does, move to other locations as well.

Thus, as shown in Figure 1, the incubator of the invention is constructed for use in an analyzer 10 comprising a sample supply station 12, a cuvette supply station 14, Figure 2, a reagent supply station 16, Figure 1, incubator 50, means 20 and 22 for transferring sample and reagent to a cuvette disposed in an outer ring of incubator 50, signal reagent supply station 24, means 26 for transferring signal reagent to the cuvette in an inner ring of incubator 50, cuvette wash station 30, and luminometer 32. Except for the incubator and the location of the stations for reagent addition described hereinafter, any suitable construction, including conventional devices, can be used for the sample supply station 12, cuvette supply station 14, reagent supply station 16, transfer means 20, 22 and 26, signal reagent supply station 24, wash dispenser 30, and luminometer 32. For example, the following features are considered to be conventional: supply station 12 includes a position having a device 13 therein which is aligned for sample transfer. Useful devices 13 include those described in commonly owned European patent application no. 93 200 886.5 (corresponding to US patent application serial no. 859780 filed on March 30, 1992.) Supply station 16 includes a rotor 34, transfer means 20, 22 and 26 are all preferably pivoting aspirators, the aspirator at transfer means 26 having dual probes 36. Transfer means 20 preferably uses disposable tips, which can be presented for

pick-up on supply station 12. Additional tips 37 can be presented on turntable 38 for use by means 20 during a dilution step. On the other hand, the aspirator for transfer means 22 preferably uses a more permanent dispensing tip, which uses a wash station 40 as is conventional.

Cuvettes can be disposed for dispensing at station 14 by mounting them in, for example, a ring 42 that moves with rotor 16, any suitable pusher 43, Figure 2, being used to displace a cuvette from ring 42 into incubator 50 below.

Although any cuvette can be used, preferably it is a cup-like container "C", having on its inside wall surface 44 an antibody pre-attached to the wall surface. The antibody is useful in a conventional sandwich assay which produces a complex of antibody-antigen-labeled antibody for generating a chemiluminescent signal.

In accordance with the invention, incubator 50 comprises two concentrically mounted support rings 52, 54 for receiving and carrying cuvettes C (delivered preferably first to ring 52 by any pusher means 43), rotating means for independently rotating rings 52 and 54 about a common axis 55, moving means 200 (Figure 3) discussed hereinafter, for moving a cuvette, in the direction of arrow 56 in Figure 2, from ring 52 to 54, processing stations around the rings, and heating means to incubate the contents of the cuvettes on rings 52 and 54. Rings 52 and 54 are shown only schematically in Figure 2 in association with the related components. Rotating means for the rings preferably comprise gear teeth 62, 64 disposed on each of rings 52 and 54, respectively, to be driven by pinion gears 66 and 68.

As noted above, various processing stations are disposed around the circumference of rings 52 and 54, in addition to an entrance port 70 for cuvettes C. They are as follows, Figures 1 and 2: Station 72 is permanently disposed above ring 52 and is the place where the dispensing tip 37 of aspirator 20 (not shown in Figure 2) descends to dispense sample into a cuvette in ring 52. First reagent addition station 74 is permanently disposed at least above ring 52 so that the permanent tip of aspirator 22 can dispense at least a first reagent into a cuvette in ring 52. Optionally, aspirator 22 can also be used to dispense a second reagent, namely a conjugate reagent, as well. Second reagent addition station 76, here for signal reagent, is disposed permanently above at least inner ring 54, to descend to dispense signal reagent into a cuvette in ring 54. Wash dispensing station 78 is disposed permanently above ring 54 for washing cuvettes using wash dispenser 30. Luminometer 32 is permanently disposed above ring 54 for reading chemiluminescence. Finally, transfer means 200 (Figures 3 and 14 to 16) is disposed at station 80 to transfer cuvettes from ring 52 to ring 54, in the direction of arrow 56 in Figure 2, and then from ring 54 to a dump, in the direction of arrow 82, or back to ring 52 temporarily. Although not shown, reagent addition stations 74 and 76 can be constructed to bridge both rings, if desired, so as to allow the respective transfer means to supply reagent to both rings, albeit in separate sequences.

The temperature control for rings 52 and 54 comprise any conventional heating mechanism, such as heater elements (not shown) disposed in a cover plate 90, shown in phantom, and in stationary support tracks, for example, track 100 disposed below both the rings, described hereinafter. Cover plate 90 is apertured at the processing stations, such as entrance port 70, an access port 102 for station 74, and the others not shown in the rest of the cover plate needed for stations 76, 78 and luminometer 32. Additionally, cover plate 90 is removed at groove 104 at station 80 to accommodate transfer means 200, shown hereinafter..

Outer ring 52, Figures 3 to 6, preferably comprises an annulus defined principally by a continuous outer shoulder 110, Figures 4 to 6, having an outside radius R_1 extending from axis 55, Figure 5. To define slots 112 for each cuvette, notches are formed in the annulus from the inside surface 114 of the annulus having an inside radius of curvature R_2. The notches are open towards axis 55, so that a cuvette C (in phantom) can be moved from outer ring 52 to the inner ring and back if necessary. Between each notch 112 there is a spoke fragment 116 shaped to support a cuvette C on top of ring 52, Figure 7. Although spokes 116 can have a variety of cross-sectional shapes, preferred is one which is an upside-down T such that the top portion "t" of cuvette C is held between fixed shoulders 118 to prevent pivoting about point 120, arrow 122. Shoulders 118 are particularly useful if track 100 is provided with optional ribs 160, as shown, as shoulders 118 then reduce the rocking motion 122 that would otherwise be induced.

As shown in Figure 6, gear teeth 62 preferably depend from the bottom portion of ring 52.

Inner ring 54 comprises, Figures 4 , 8 and 9, a base annulus 130 extending completely around the circumference and having an inside radius of curvature R_3 measured from axis 55, Figure 8. Mounted preferably on the inside portion of annulus 130 is a skirt with gear teeth 64, Figure 9. Extending upward and outwardly away from annulus 130 at spaced intervals, with an outside radius R_4, Figure 8, are wide flanges 134 and narrow flanges 136, spaced apart to define notches 142, each shaped to receive and carry a cuvette C (shown in phantom). Most preferably, notches 142 are in pairs with a narrow flange 136 dividing up each pair. The pitch P_1 between each of every other pair is con-

trolled to match the angular spacing around the circumference of stations 76, 78 and 32. Pitch P_2 for the intermediate set of pairs equals pitch P_1, but the spacing d_1 and d_2 which positions each pair from its adjacent pair need not be equal.

Each flange 134 and 136 is shaped in cross-section as an upside down "T", similar to the spokes 116 of ring 52, Figure 7, to provide a shoulder 144 to support upper portion "t" of the cuvette (in phantom).

Importantly, notches 142 differ from notches 112 of ring 52 in that they are open in both directions, away and towards axis 55, Figures 4 and 9. This is needed to allow a cuvette to be moved into ring 54 from ring 52, and then into the dump, as indicated by arrow 82 in Figure 1, which is inside annulus 130.

Each of rings 52 and 54 includes flag means (not shown) which allow either a "home" position, or each cuvette position, to be sensed by a conventional sensor.

Turning next to stationary tracks 100, 100', Figures 11 and 12, these can have a variety of surface configurations. If cuvettes C are agitated while on rings 52 and 54 by some other mechanism, then the top surface of tracks 100 can be smooth, except for rails 150, 152 and 154, described hereinafter. Preferably, the top surface of each track is provided with ribs 160, to cause cuvettes C to be agitated.

More specifically, Figures 10 and 17, tracks 100 and 100' are provided with an outside guide rail 150 that runs along outside of the path of cuvettes C carried by ring 52, Figure 17. Track 100' is provided with an inside guide rail 152 which runs along inside of the path of cuvettes C' carried by ring 54, and a guide rail 154 is disposed between the aforesaid two tracks and hence between rings 52 and 54. Rails 150, 152 and 154 serve to retain the cuvettes from being inadvertently displaced sideways, towards or away from axis 55.

However, Figure 10, only guide rail 150 extends completely around the circumference of track 100. Guide rail 152 is continuous except for notch 156 at station 80, so that cuvettes C', Figure 16, can be dumped from ring 54. Guide rail 154 is the same as rail 152 - it is continuous except for a notch 158 at station 80, to allow transfer of cuvettes from ring 52 to ring 54.

As noted above, tracks 100 and 100' between paired rails 150, 152, and 154 can be smooth, but are preferably provided with ribs 160, as are more clearly shown in Figures 11 and 12. The pitch "p" and height "h" are adjusted to give agitation to the contents of cuvettes C and C' to cause mixing but without spilling liquid from the cuvettes. The values of p and h depend on the rate of mixing which is desired, as well as the speed of transit over the ribs and the height of the cuvette. Further, pitch p can be different for each track, if the transit speed is different. As an example, for a transit speed of between 20cm/s and 60cm/s, and a cuvette height of 12mm, "h" can vary between 0.6mm and 3.0mm, and "p" can vary between 1mm and 5.0mm, with angle α, Figure 12, being between 40° and 50°. Because of restraining shoulders 118 and 144, the cuvettes are induced to "bump" over the ribs, within the confines of cover plate 90, Figure 17, that is, cover 90, Figures 7 and 17, assists in preventing the cuvettes from rising too far out of their notches.

Means are needed for moving cuvettes from ring 52 to ring 54, and then off ring 54 out to dump. To that end, at station 80 there is provided transfer means 200, Figures 13 to 16. Such means comprise preferably a push rod 202, 204 for each of the outer and inner rings 52 and 54, respectively, mounted for transverse, reciprocal movement above their respective rings. Each rod has a terminal lip 206, Figures 14 to 16, which depends down far enough to engage any cuvette which is aligned therewith when the rod is pulled towards axis 55. To reciprocate each rod, a drive can be provided for each. Preferably, however, only rod 204 is driven (along tracks 205, Figure 13), by reason of the rod being internally threaded to engage a lead screw 208 driven by stepper motor 210. Rod 202, on the other hand, is a follower rod which is slidably and freely mounted on track 212, with tabs 214 and 216 rising therefrom, Figures 14 to 16, to be engaged by a collar 218 on rod 204 which encircles rod 202.

The operation of transfer means 200 will be readily apparent from the preceding. As shown in Figures 14 to 16, when a cuvette shown in phantom needs to be transferred at station 80 from ring 52 to ring 54, push rod 204 is drawn back, in the direction of arrow 220, by lead screw 208, until collar 218 engages tab 214. This causes rod 202 to also traverse towards axis 55, from its phantom position, causing lip 206 thereof to move cuvette C to its solid position on ring 54. The next part of the cycle of movement, Figure 15, is to move both rods to the outside of their respective rings, and this is done by advancing lead screw 208 and rod 204 away from axis 55 until collar 218 presses against tab 216 and pushes out rod 202 as well, from its solid position to that shown in phantom (between spaces occupied by cuvettes).

The last part of the cycle of movement is that used to transfer a cuvette C' from ring 54 to dump, Figure 16, at station 80. Lead screw 208 simply withdraws enough to cause lip 206 of rod 204 to pull cuvette C' off ring 54.

It will be understood that one of the notches 142 is maintained empty of cuvettes to provide

clearance for movement of lip 206 between rings.

Alternatively, in some assays the cuvette is transferred back to outer ring 52 for further reagent addition and incubation, before returning to ring 54 for washing and reading.

In addition to heated cover 90 and stationary tracks 100, 100', additional insulative enclosures are preferably provided, Figure 17, to retain the heat for incubation of incubator 50. That is, a housing 300 is mounted on a base 302 of an insulative material, with suitable apertures 304 positioned for access to the incubator. Those apertures are generally aligned with the apertures of cover 90, Figure 2. Most preferably, apertures 304 are removably covered by doors 310, which can be operated by any suitable means, such as a cam 312 driven by motor 314 to engage cam followers 316 on the doors. Most preferably, drive shaft 320 of motor 314 is on axis 55, Figure 17.

The actual control of the temperature within incubator 50 is variable, depending on the reactions desired. Most preferably, the temperature of outer ring 52 is preferably kept within 0.5° of the desired temperature, for example, of 37°, as most of the incubation occurs while on this ring. Inner ring 54, on the other hand, can be within 2° of the desired target temperature, but most preferably ±0.5°C.

The timing sequence for the operation of the incubator will of course depend upon a large variety of factors, including a) the angular position of each processing station about the rings of the incubator, and b) the chemistry of the immunoassays in question, as will be readily apparent.

A representative timing diagram is given in Figures 18A and 18B. In this diagram, it is assumed that reagent transfer means 22 goes to reagent supply station 16, Figure 1, twice for two different reagents. The first 15 functions are defined as operations pertaining to outer ring 52, whereas the remainder are for inner ring 54.

Considering the overall operation of the incubator, it proceeds as follows, under the control of conventional computing means (not shown). ("Step" numerals appear in parentheses in Figures 18A and B, and "SGR" is an abbreviation for "signal reagent".)

Step 1: a cuvette C is dropped into a notch in outer ring 52.

Step 2: ring 52 is rotated to move that cuvette into position at station 72 (Figure 2) to receive a sample liquid.

Step 3: sample is dispensed at station 72.

Step 4: ring 52 is rotated to move the cuvette to reagent addition station 74 (Figure 2).

Step 5: reagent is dispensed at station 74 using transfer means 22.

Step 5': rotate ring 52 to allow other operations on other cuvettes, while incubating and agitating this cuvette.

Step 6: rotate ring 52 to move it back to station 74 for optional conjugate reagent addition.

Step 7: dispense second reagent, if needed.

Step 8 (not labeled on Figure 18): incubate and agitate for a minimum of 15 minutes.

Step 9: rotate ring 52 (and ring 54) to place cuvette at station 80.

Step 10: activate transfer means 200 to move cuvette from ring 52 to ring 54.

Step 11: align cuvette on ring 54 at station 78 for washing of the cuvette.

Step 12: wash cuvette at station 78.

Step 13: repeat alignment step 11 until cuvette is at station 76.

Step 14: dispense signal reagent at station 76.

Step 15: repeat alignment step 11 until cuvette is at read station 32.

Step 16: read cuvette with the luminometer.

Step 17: repeat step 11 until cuvette is at station 80.

Step 18: activate push rod 204 to dump the cuvette.

As noted heretofore, the plural rings need not be concentrically mounted -- indeed they need not be one within the other, Figures 19 and 20. Parts similar to those previously described bear the same reference numeral to which the distinguishing suffix "A" is appended. Thus, rings 52A and 54A can be side-by-side, separately rotated about separate axes by gears 66A and 68A, Figure 19. The various stations 14A, 72A, 74A are disposed adjacent ring 52A as before, whereas stations 32A, 76A and 78A are disposed adjacent ring 54A as before. Each ring 52A and 54A, Figure 20, is preferably notched at 112A and 142A, respectively, so that the notches open outwardly only, to allow transfer at station 80A of a cuvette "C", between rings using transfer means 200A. Fixed track 100A and 100'A are separate annuli which surround only their respective rings.

The invention disclosed herein may be practised in the absence of any element which is not specifically disclosed herein.

Claims

1. An incubator (50) in an analyzer (10) for detecting an analyte, the incubator (50) comprising:-

stationary guide track means (100, 100'; 100A, 100A');

a plurality of processing stations (12, 14, 16, 24, 30, 32, 72, 74, 76, 78, 80; 14A, 32A, 72A, 74A, 76A, 78A, 80A) arranged around the guide track means (100, 100'; 100A, 100A');

support means (52, 54; 52A, 54A) mounted above the guide track means (100, 100'; 100A, 100A') and operable for carrying reaction cuvettes (C) between the processing stations (12, 14, 16, 24, 30, 32, 72, 74, 76, 78, 80; 14A, 32A, 72A, 74A, 76A, 78A, 80A), the reaction cuvettes (C) being held at defined positions in the support means (52, 54; 52A; 54A), each position being formed as an opening in the support means (52, 54; 52A; 54A) sized to receive and to hold the reaction cuvettes (C);

drive means (62, 64, 66, 68; 66A, 68A) for rotating the support means (52, 54; 52A, 54A) between the processing stations (12, 14, 16, 24, 30, 32, 72, 74, 76, 78, 80; 14A, 32A, 72A, 74A, 76A, 78A, 80A);

temperature control means (90) adjacent the support means (52, 54; 52A, 54A); and

transfer means (200, 202, 204, 206, 208, 210, 212, 214, 216, 218; 200A) for transferring a reaction cuvette (C) from one position in the support means (52, 54; 52A, 54A) to another at a transfer location (80; 80A);

characterized in that the support means (52, 54; 52A, 54A) comprises plural support rings, at least one ring (54; 52A, 54A) having a modified opening to allow transfer of cuvettes (C) from one ring to the other;

and in that the transfer means (200, 202, 204, 206, 208, 210, 212, 214, 216, 218; 200A) operates to transfer a cuvette (C) from one ring to the other at the transfer location (80; 80A) and/or from one ring to a dump station.

2. An incubator according to claim 1, wherein the plural rings comprise two concentrically mounted rings (52, 54).

3. An incubator according to claim 2, wherein each ring (52, 54) is rotated independently about an axis (55) above the stationary track (100, 100'), the stationary track (100, 100') having opposing guide rails (150, 152, 154) on at least portions thereof to prevent sideways displacement of the cuvettes (C) towards or away from the axis (55).

4. An incubator according to claim 3, wherein one of the guide rails (154) is disposed between two of the rings (52, 54), and is notched at the transfer location (80) to allow movement of a cuvette (C) from one ring to the other.

5. An incubator according to claim 4, wherein another guide rail (152) is disposed around the inside of the innermost ring (54), and is notched sufficiently to allow a cuvette (C) to be removed from the inside ring (54) inwardly towards the common axis (55).

6. An incubator according to claim 1, wherein the plural rings comprise two rings (52A, 54A) arranged side by side and interconnected at the transfer location (80A) by the transfer means (200A).

7. An incubator (50) in an analyzer (10) for detecting an analyte, the incubator (50) comprising:-

a stationary guide track (100, 100'; 100A, 100A');

plural support rings (52, 54; 52A; 54A) above the track (100, 100'; 100A, 100A') for carrying reaction cuvettes (C) around the incubator (50), the reaction cuvettes (C) being held at defined positions in the rings (52, 54; 52A, 54A), each position comprising an opening in the rings (52, 54; 52A, 54A) sized to receive and hold the reaction cuvettes (C);

processing stations (12, 14, 16, 24, 30, 32, 72, 74, 76, 78, 80; 14A, 32A, 72A, 74A, 76A, 78A, 80A) adjacent to the rings (52, 54; 52A, 54A) to provide separately means for the functions of sample addition (12, 14; 14A), first liquid reagent addition (74; 74A), second liquid reagent addition (76; 76A), cuvette washing (30, 78; 78A), optional third liquid reagent addition, and detection (32; 32A) of light emitted from the reaction cuvettes (C), at least the first liquid reagent addition station (74; 74A) being permanently disposed adjacent to at least one (52; 52A) of the rings (52, 54; 52A, 54A), while at least the second liquid reagent addition station (76; 76A) is permanently disposed adjacent to at least another (54; 54A) of the rings (52, 54; 52A; 54A);

drive means (62, 64, 66, 68; 66A; 68A) for rotating each of the support rings (52, 54; 52A, 54A) independently between the processing stations (12, 14, 16, 24, 30, 32, 72, 74, 76, 78, 80; 14A, 32A, 72A, 74A, 76A, 78A, 80A);

transfer means (200, 202, 204, 206, 208, 210, 212, 214, 216, 218; 200A) for transferring a reaction cuvette (C) from one support ring (52; 52A) to the other (54, 54A) at a transfer location (80; 80A), or off the rings (54, 54A), at an appropriate stage within the incubator (50), the transfer means (200, 202, 204, 206, 208, 210, 212, 214, 216, 218; 200A) including in at least one of the rings (54; 54A) a passageway notch extending from each of the openings to a dump position on the ring (54; 54A), the notch and the stationary guide track (100'; 100A') being constructed to allow a cuvette (C) to be dumped at the dump position; and

temperature control means (90) adjacent to

both of the rings (52, 54; 52A, 54A),

characterized in that a higher number of detected analytes per hour is achieved by separating and distributing the incubating functions on to more than one support ring than is achieved using only one such ring.

8. A method for incubating cuvettes in an incubator according to any one of the preceding claims, the method comprising the steps of:-

a) placing a cuvette and liquid sample in a defined position on one of the support rings (52; 52A),

b) rotating the one support ring (52; 52A) between processing stations (12, 14, 16, 24, 30, 32, 72, 74, 76, 78, 80; 14A, 32A, 72A, 74A, 80A) disposed adjacent to the support ring (52; 52A) while incubating the contents of the cuvette (C),

c) transferring the cuvette (C) to another of the support rings (54; 54A) following partial incubation at a transfer location (80; 80A),

d) rotating the other support ring (54; 54A) while incubating the contents of the cuvette (C) and while passing through at least one reagent-addition station, and

e) ejecting the cuvette (C) from the incubator by moving it through a notch in the other ring (54; 54A).

9. A method according to claim 8, further including the step of washing the cuvette (C) while on the other support ring (54; 54A).

10. A method according to claim 8 or 9, wherein the rotation of the other ring (54; 54A) is achieved independently of the rotation of the one ring (52; 52A).

11. A method according to claim 8, further including the step of transferring the cuvette (C) back to the one ring (52; 52A) from the other ring (54; 54A) for further incubation.

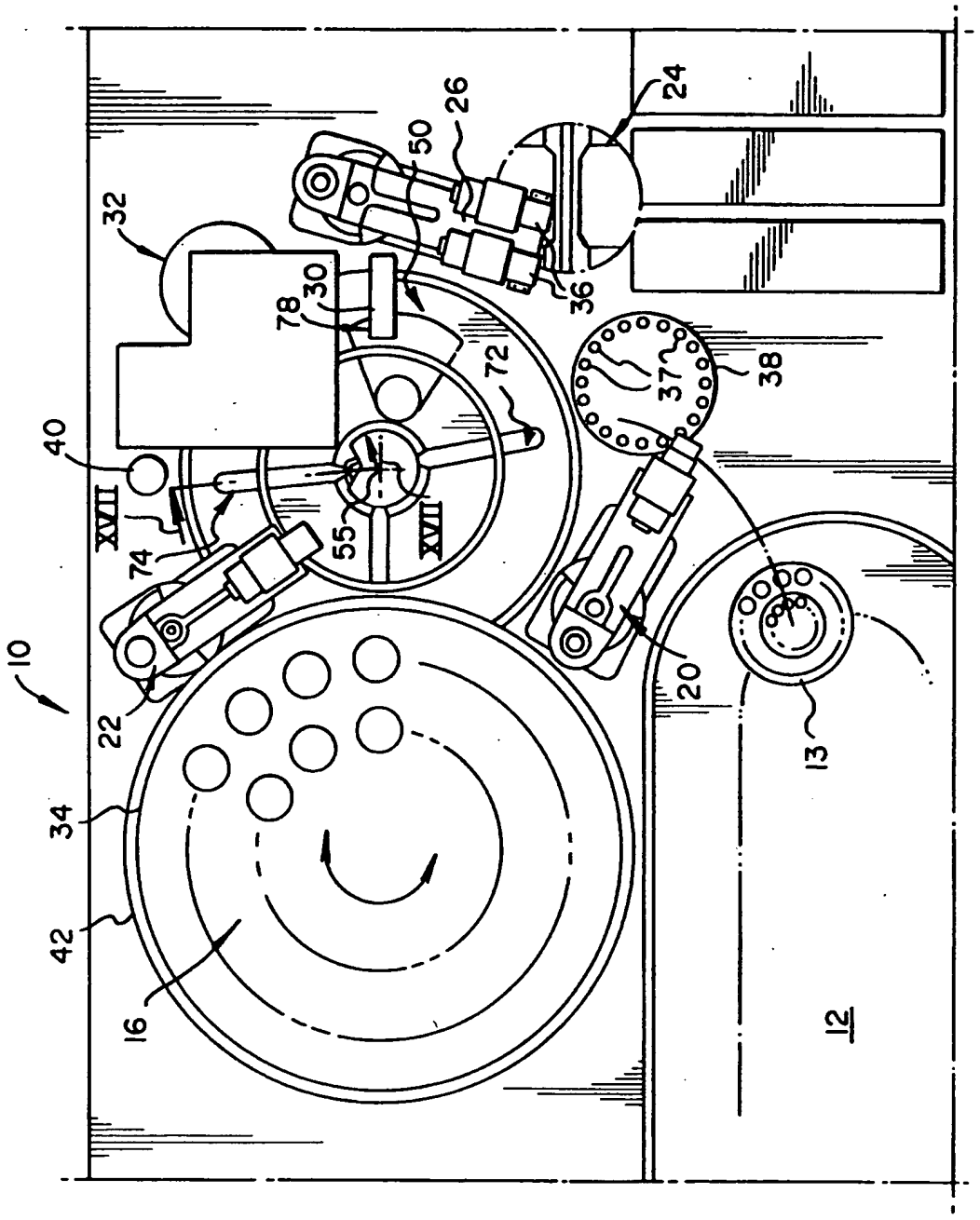

10
12
13
16
20
22
24
26
30
32
34
36
37
38
40
42
50
55
72
74
78
XVII
XVII

FIG. 1

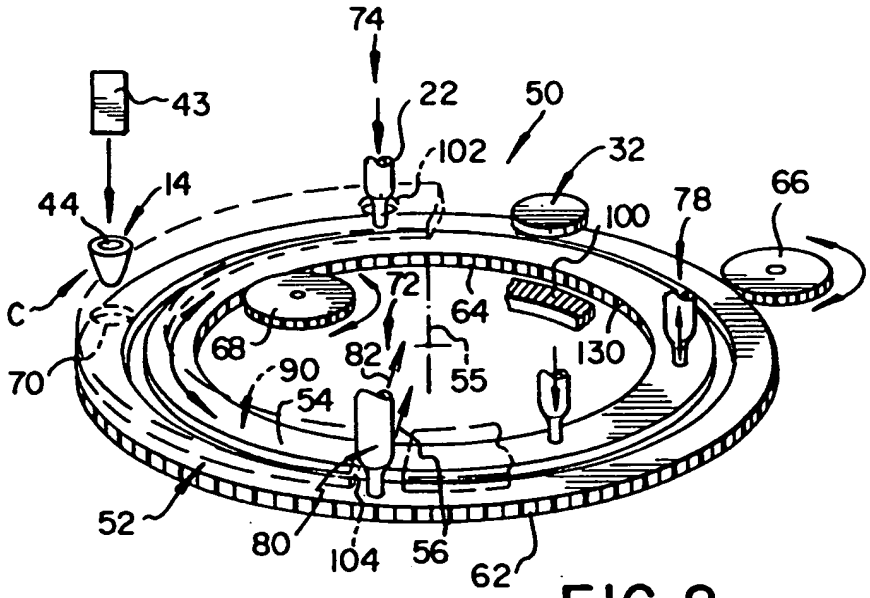

74
43
22
50
102
32
44
14
100
78
66
C
72
64
68
82
130
70
90
55
54
52
80
104
56
62

FIG. 2

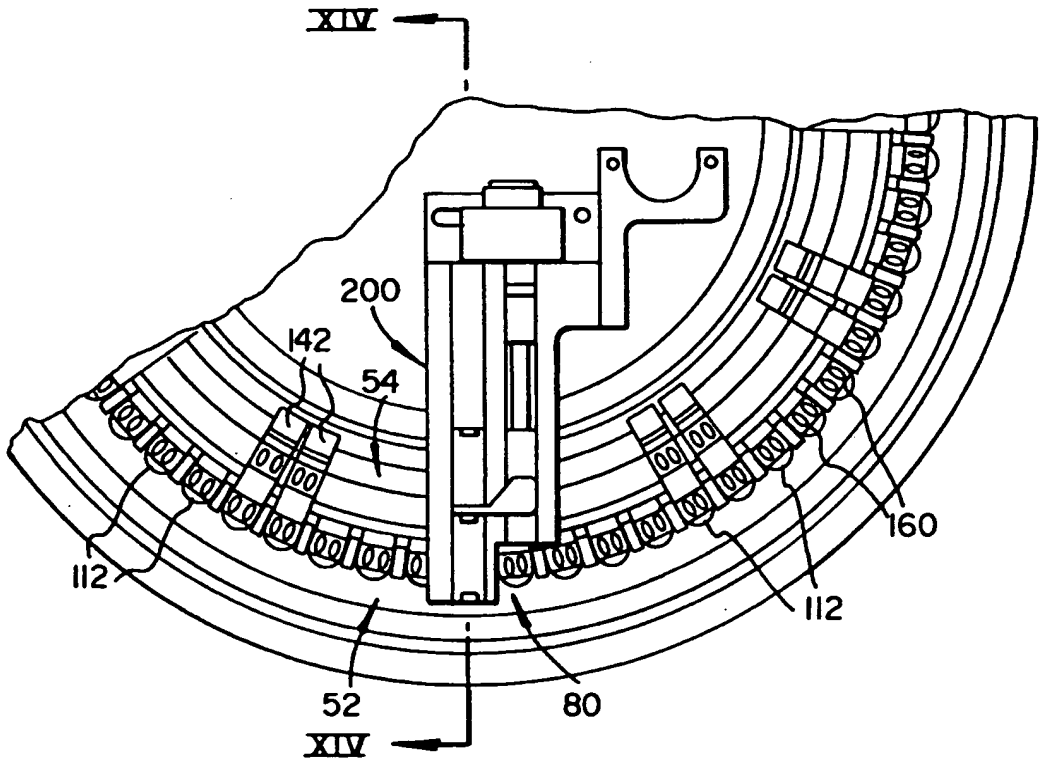

XIV
200
142
54
160
112
112
52
80
XIV

FIG. 3

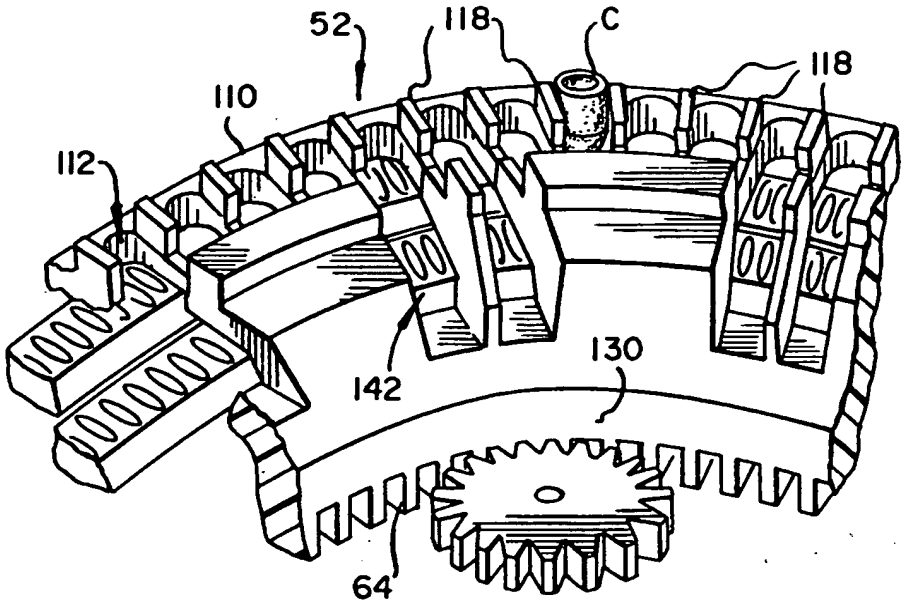


FIG. 4

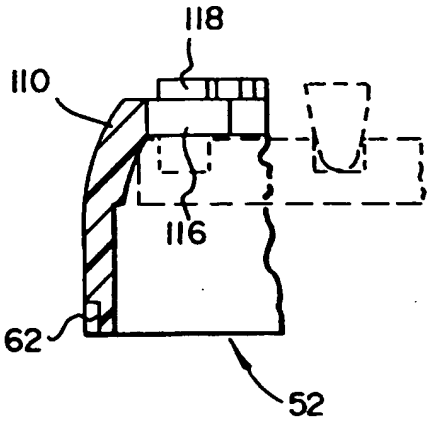


FIG. 6

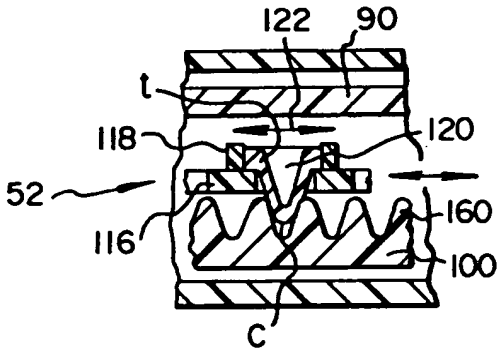


FIG. 7

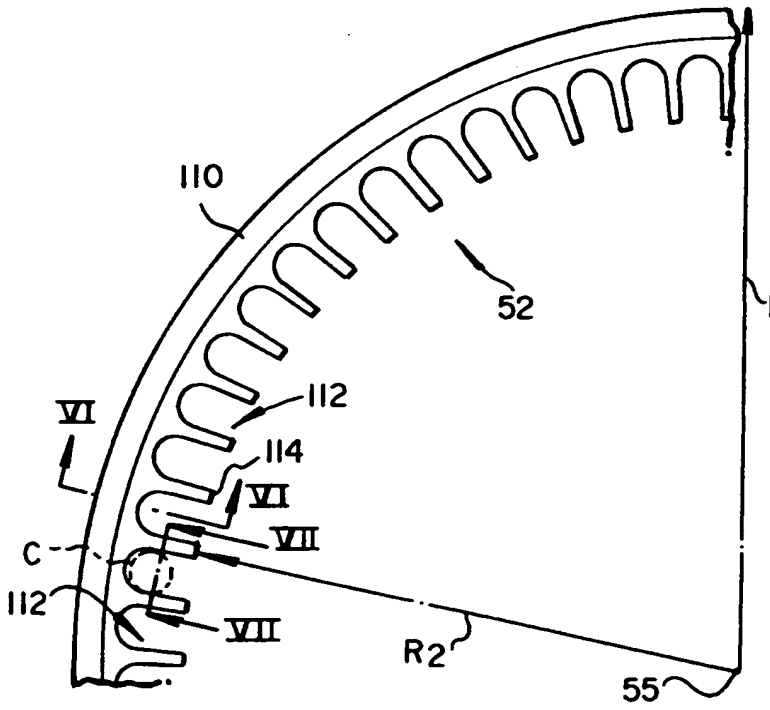


FIG. 5

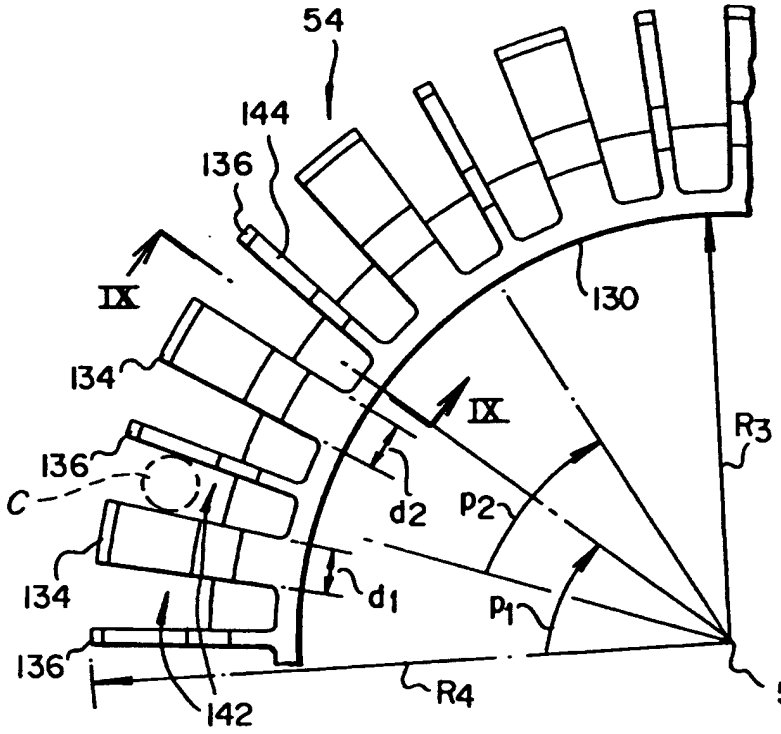


FIG. 8

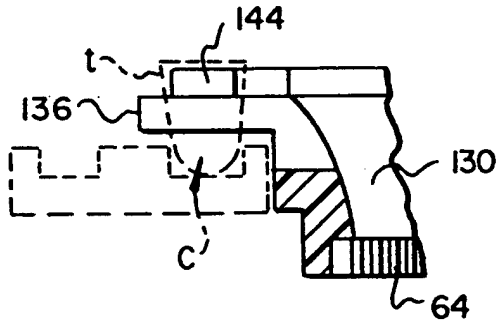


FIG. 9

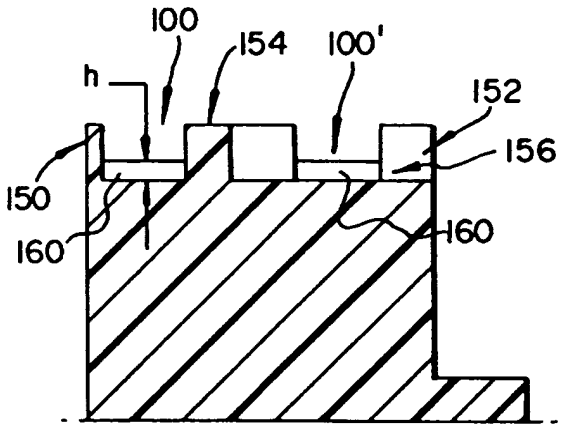


FIG. 11

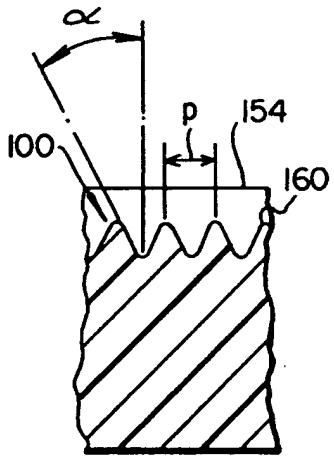
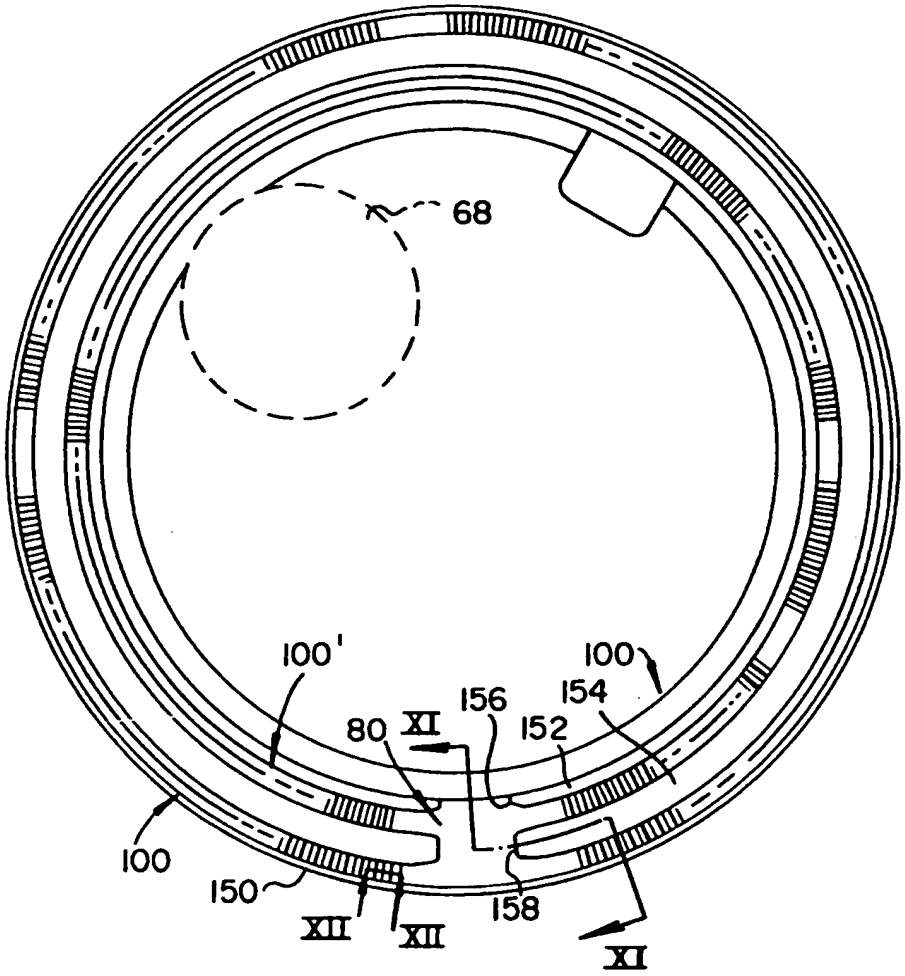


FIG. 12

FIG. 10


68
100'
100
156
154
80
XI
152
100
150
XII
XII
158
XI

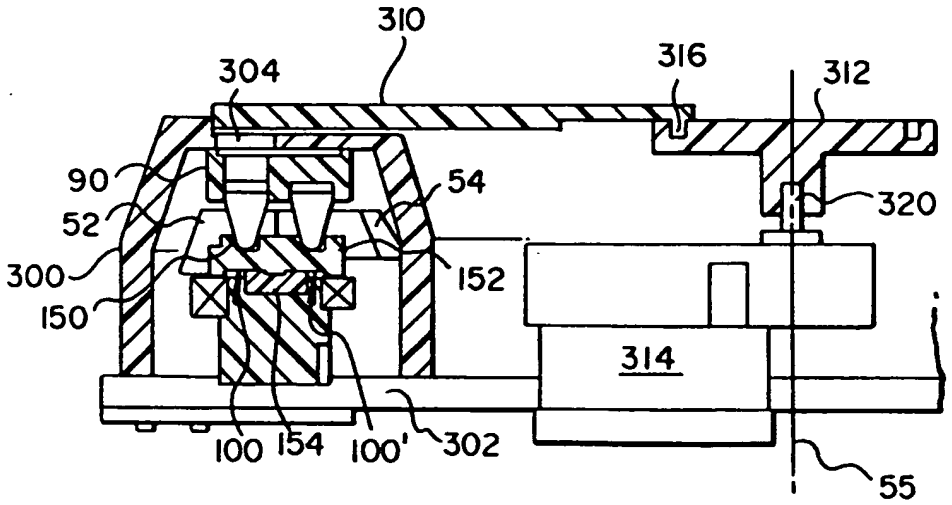

310
304
316
312
90
54
320
52
300
152
150
314
100
154
100'
302
55

FIG. 17

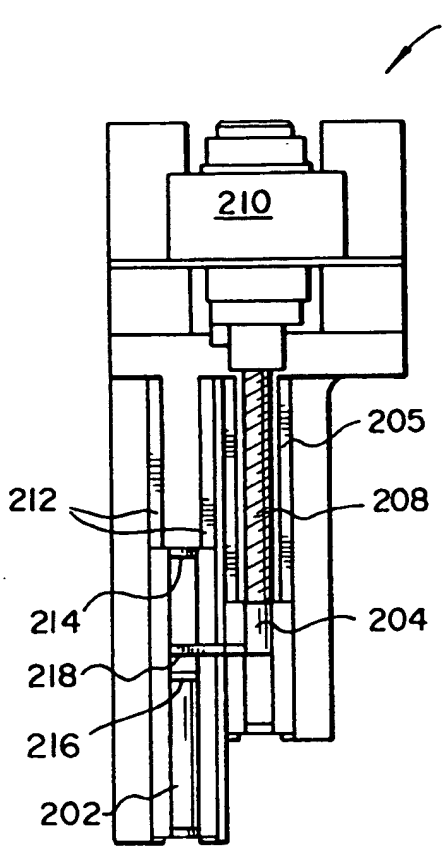

200
210
205
212
208
214
204
218
216
202

FIG. 13

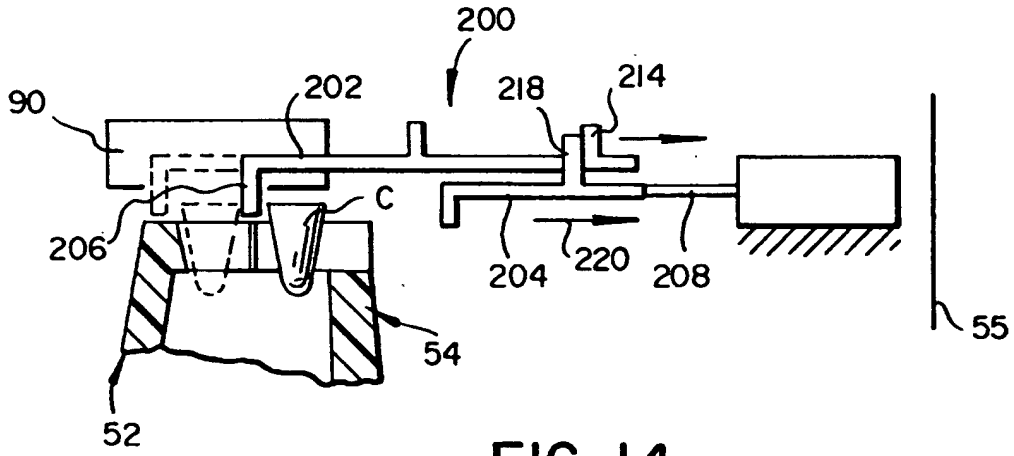

200
90
202
218
214
C
206
204
220
208
55
54
52

FIG. 14

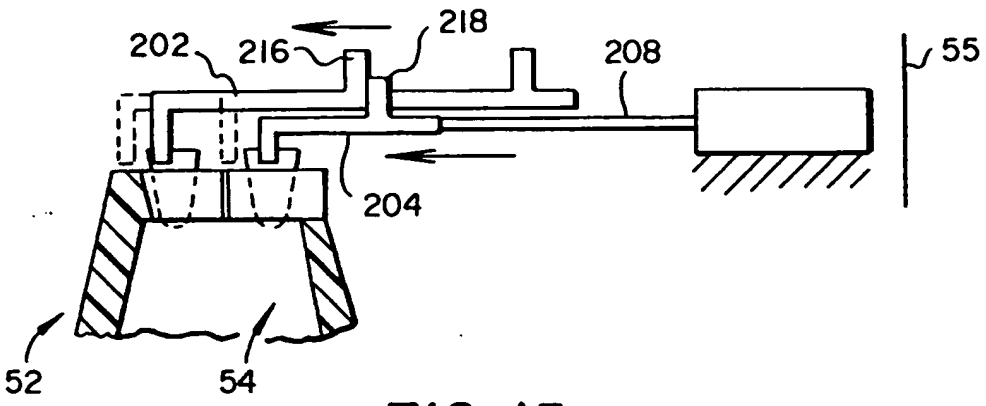


FIG. 15

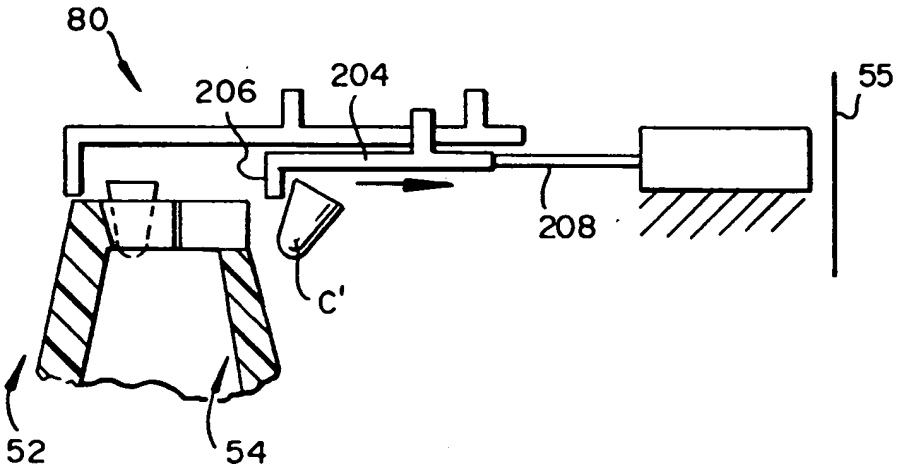


FIG. 16

FIG.18A

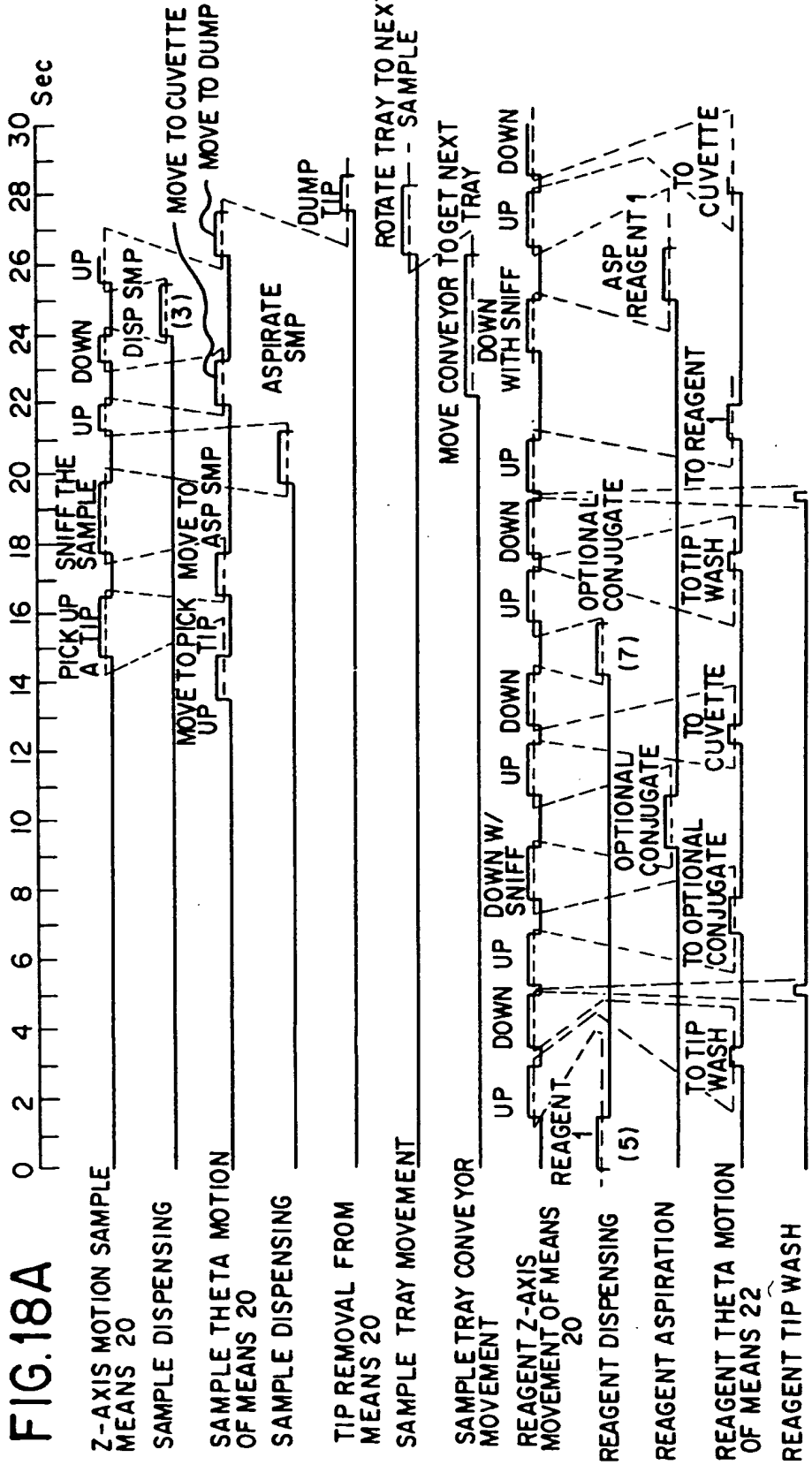
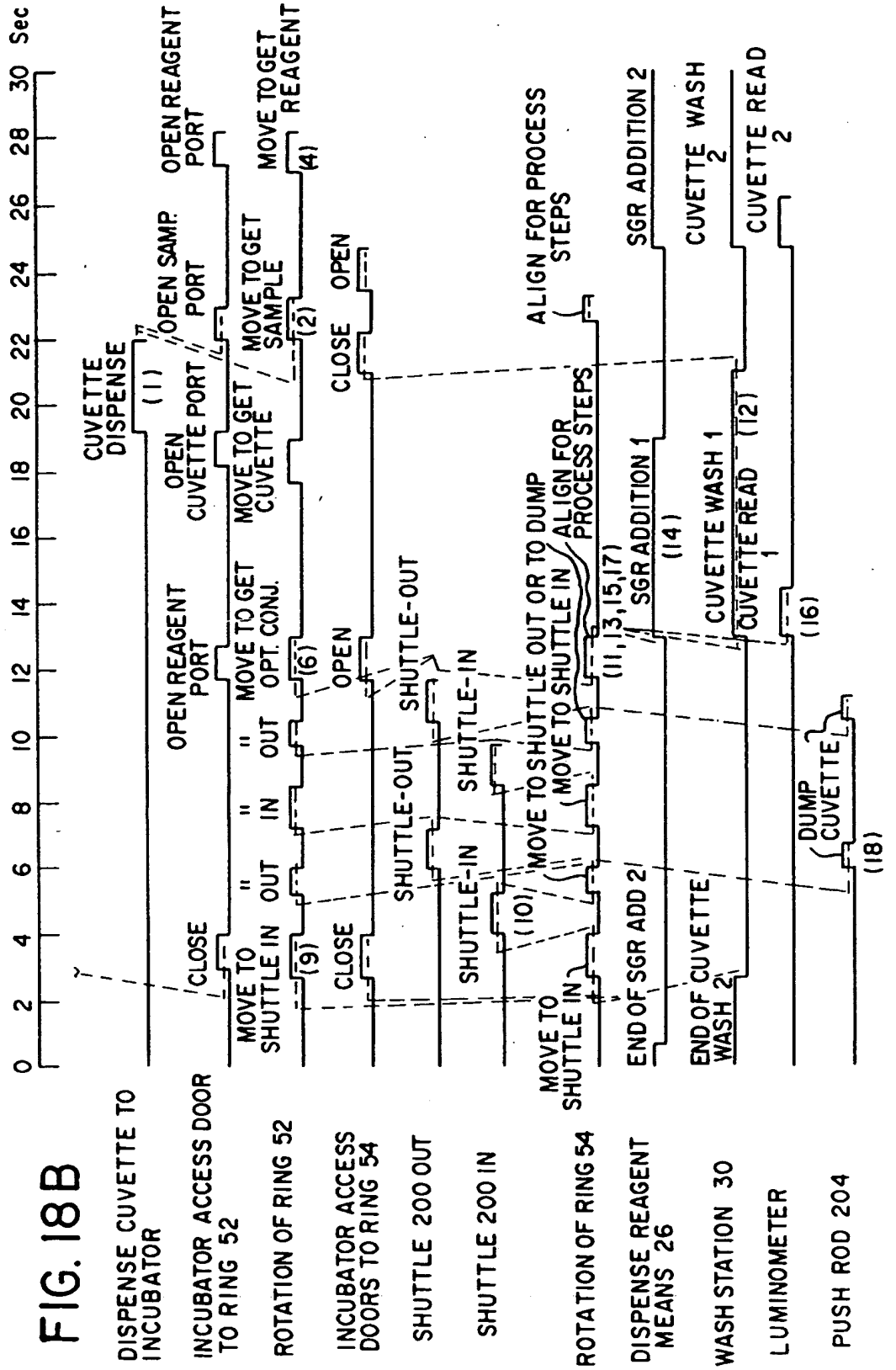

0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Sec
Z-AXIS MOTION SAMPLE MEANS 20
SAMPLE DISPENSING
SAMPLE THETA MOTION OF MEANS 20
SAMPLE DISPENSING
TIP REMOVAL FROM MEANS 20
SAMPLE TRAY MOVEMENT
SAMPLE TRAY CONVEYOR MOVEMENT
REAGENT Z-AXIS MOVEMENT OF MEANS 20
REAGENT DISPENSING
REAGENT ASPIRATION
REAGENT THETA MOTION OF MEANS 22
REAGENT TIP WASH
PICK UP A TIP
SNIFF THE SAMPLE
UP
DOWN
UP
DISP SMP
(3)
MOVE TO CUVETTE
MOVE TO DUMP
MOVE TO PICK UP TIP
MOVE TO ASP SMP
ASPIRATE SMP
DUMP TIP
ROTATE TRAY TO NEXT - SAMPLE
MOVE CONVEYOR TO GET NEXT TRAY
DOWN WITH SNIFF
UP
DOWN
UP
ASP REAGENT 1
TO CUVETTE
TO REAGENT 1
TO TIP WASH
OPTIONAL CONJUGATE
(7)
UP
DOWN
UP
DOWN W/ SNIFF
UP
DOWN
REAGENT 1
(5)
OPTIONAL CONJUGATE
TO CUVETTE
TO OPTIONAL CONJUGATE
TO TIP WASH

FIG. 18B


0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 Sec
DISPENSE CUVETTE TO INCUBATOR
INCUBATOR ACCESS DOOR TO RING 52
ROTATION OF RING 52
INCUBATOR ACCESS DOORS TO RING 54
SHUTTLE 200 OUT
SHUTTLE 200 IN
ROTATION OF RING 54
DISPENSE REAGENT MEANS 26
WASH STATION 30
LUMINOMETER
PUSH ROD 204
CUVETTE DISPENSE
(1)
OPEN SAMP. PORT
OPEN REAGENT PORT
OPEN CUVETTE PORT
MOVE TO GET CUVETTE
MOVE TO GET SAMPLE
(2)
MOVE TO GET REAGENT 1
(4)
CLOSE
MOVE TO SHUTTLE IN
" OUT
" IN
" OUT
MOVE TO GET OPT. CONJ.
(6)
(9)
CLOSE
OPEN
SHUTTLE-OUT
SHUTTLE-IN
SHUTTLE-OUT
SHUTTLE-IN
(10)
MOVE TO SHUTTLE IN
MOVE TO SHUTTLE OUT OR TO DUMP
ALIGN FOR PROCESS STEPS
ALIGN FOR PROCESS STEPS
(11,13,15,17)
SGR ADDITION 1
(14)
SGR ADDITION 2
END OF SGR ADD 2
END OF CUVETTE WASH 2
CUVETTE WASH 1
CUVETTE READ 1
(12)
CUVETTE WASH 2
CUVETTE READ 2
(16)
DUMP CUVETTE
(18)

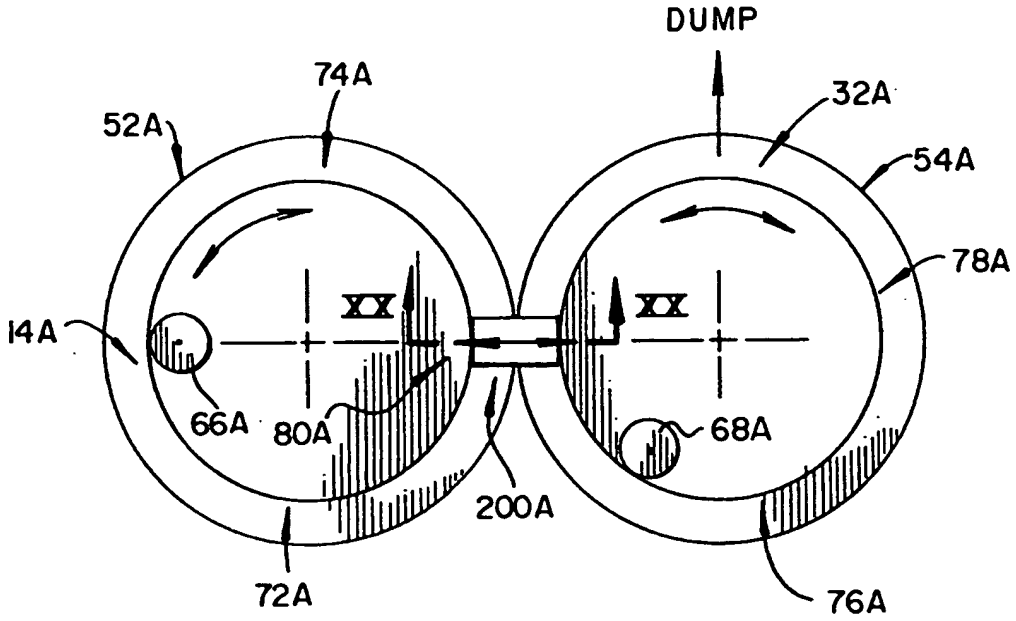

DUMP
74A
52A
32A
54A
78A
14A
XX
XX
66A
80A
68A
200A
72A
76A

FIG. 19

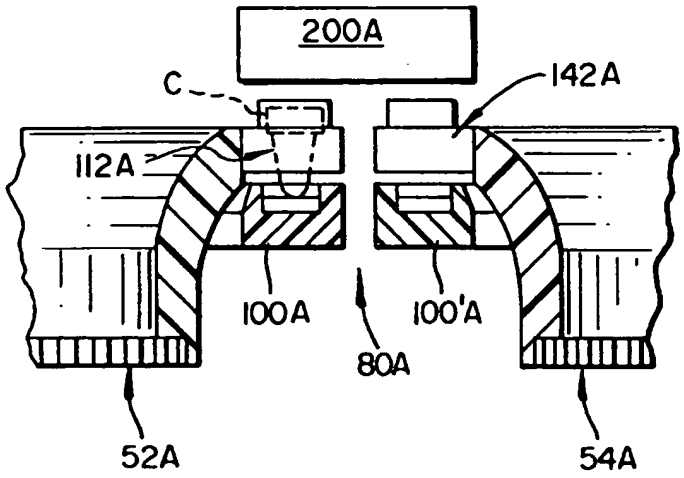

200A
C
142A
112A
100A
100'A
80A
52A
54A

FIG. 20

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93 20 1394

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X Y	US-A-3 504 376 (BEDNAR ET AL.) * column 8, line 62 - column 10, line 29; figure 7 *	1,6-8,10 2	G01N35/02
D,Y A	US-A-4 699 766 (YAMASHITA) * column 2, line 60 - column 5, line 25 *	2 3,7-10	
A	FR-A-2 280 894 (PAQUELET ET EL.) * page 4, line 31 - page 13, line 13 *	1,3,6-8	
A	US-A-4 406 547 (AIHARA) * column 6, line 30 - column 7, line 28 *	1,7,8	
A	US-A-3 751 985 (KNEDEL ET AL.) * column 6, line 31 - line 68 *	1,2	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G01N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 SEPTEMBER 1993	BINDON C.A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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